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ABSTRACT

There is disagreement about whether education for the future ought to be more general or more specific than is currently the case. Those who believe that the technologically based world of the future will require more job-specific or highly specialized skills advocate more specialized and vocational training in the schools. Those who see future work as becoming "deskilled" emphasize the importance of a broad course of studies. Evidence regarding this debate indicates that there is a pressing need to develop the type of curriculum that will best prepare students not for specific jobs but for a range of tasks required in the near future. Adaptability to change is demanded by rapid technological development, but an increasingly specialized curriculum may not produce workers able to adjust to continuing changes in the tools and conditions of work. Other skills identified as important to modern society--analysis and critical thinking, organizational and reference skills, creativity and ability to communicate--call for both general and specialized training. Thus a general foundation should be emphasized in the formative elementary and secondary years, and at the same time, high schools will need to prepare a sufficient number of highly skilled students in technical fields. (JM)

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Education and Technology: Predicting the Needs of the Future

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Our perceptions of education seem to be tracing a path similar to that of a pendulum. In times of prosperity and national pre-eminence, we laud education, broaden our educational offerings, and focus our attention on educational access. During periods of economic distress and national embarrassment, we denigrate our institutions of learning, narrow program options, and concentrate on excellence rather than access.

Because of the current economic decline and the fear that America may be losing its position of technological superiority, much has been written about the need to reshape our educational system to better meet the needs of business and high technology. Representatives of industry, government, and schools warn of the inadequate pool of workers skilled enough to contribute to our technological advancement.

Some find the answer to the problem in the increased allocation of resources to vocational education, career education, studies in science and math, work/study programs, or courses in the use of micro-computers. These answers tend to lead down the path of increasing specialization.

Others argue the merits of a liberal course of study that prepares students to adapt to a rapidly changing society by imparting general skills. Those defending a general curriculum envision the mission of education as offering, in the words of Ted Mills, "a taste of human wisdom, an understanding of inner human needs, the meaning of self-worth." In some cases, the humanist perceives education as compensating for the rigor, tedium, and dissatisfaction characterizing many jobs.

In fact, the desires of proponents of a liberal education and those who argue the advantages of an education more relevant to the workplace need not be mutually exclusive. The differentiated needs of students suggest that the curriculum should be both broad and specialized. In reviewing research on the effects of technology on skill requirements, this article attempts to identify those skills needed generally and those that are peculiar to higher level jobs. It then suggests implications for curricular programs based on these needs.

The Effects of Technology

Technology is substantially altering our lives, especially through the expanding application of microcomputers to all phases of human activity. It would seem

reasonable to conclude, then, that school curricula will inevitably need to accomodate demands for increased knowledge and skills necessary for the design and use of new technology.

Some social scientists, such as Peter Blau, Wilbert Moore, and Wickham Skinner, have argued that new technology increases the differentiation and specialization of labor and affords workers higher levels of responsibility and skill. Concurring with this judgment are certain economists who point out that the differences in wages for skilled and unskilled workers have narrowed with increasing technology, an indication that technological advancement has upgraded unskilled jobs.

Lynn Grover Gisi and Roy Forbes of the Education Commission of the States have recently completed an evaluation of skills needed for our modern society. Based on their study, they have compiled a list of the "basics" that should be mastered by future workers:

* evaluative and analytical skills
* critical thinking
* problem-solving
* organizational and reference skills
* synthesis
* application
* creativity
* decision-making (with incomplete information)
* communication skills (using a variety of modes)

In contrast to the argument that technology raises skill levels, Harry Braverman, Ivar Berg, and others contend that technology may actually lower the skills required in most work. Berg examined the educational requirements for about 4,000 jobs for which educational and training requirements were estimated first in 1957 and then again in 1965. By adjusting these data so that they could be correlated with census reports on the educational achievements of the work force by occupation, he was able to calculate the approximate relationship of educational requirements for jobs to the educational achievements of the American labor force. He concluded that "since 'achievements' appear to have exceeded requirements in most job categories, it cannot be argued helpfully that technological and related changes attending most jobs account for the pattern whereby better-educated personnel are 'required' and utilized by managers."

The desires of proponents of a liberal education and those who argue the advantages of an education more relevant to the workplace need not be mutually exclusive.

Braverman argues that, in the capitalist system, managers find it expedient and cost-effective to fragment and routinize jobs over time, irrespective of the skills workers possess. In fact, Braverman finds that the changing conditions of industrial and office work result in a polarization of the skills possessed by managers and those possessed by workers. It is the managers and engineers who gain upgraded skills and are able to manipulate new technology. Meanwhile, at the other end,

> the more science is incorporated into the labor process, the less the worker understands of the process; the more sophisticated an intellectual product the machine becomes, the less control and comprehension of the machine the worker has. In other words, the more the worker needs to know in order to remain a human being at work, the less does he or she know.

Braverman's concern for the worker as human being raises the issue of job satisfaction and self-concept. Training students for the workplace is not simply a matter of matching skills to jobs.

In many cases, technology has transformed skilled workers into intelligent machine tenders. An

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The Center for Educational Policy and Management (CEPM) is devoting increased attention to the policy implications of the debate over the contribution of education to productivity. Plans are underway for the Center to participate in a study of successes in secondary educational programs that graduate students with the cognitive skills necessary for further specialized training in occupations involving modern technology. Researchers for CEPM will be exploring the effects of particular educational programs on graduates' employability and initial job success.

The material for this issue of R&D Perspectives *was extracted from a larger paper,* The Contribution of Education to Productivity, *commissioned by the ERIC Clearinghouse on Educational Management at the University of Oregon. Wynn De Bevoise, editor of* R&D Perspectives, *wrote the paper while employed by the Clearinghouse as a research analyst and writer. Readers may obtain information about ordering the full text of the monograph, to be published in March 1983, by writing Editor, ERIC Clearinghouse on Educational Management, College of Education, University of Oregon, Eugene, OR 97403.*

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example of this transformation is afforded by Western Electric Company's manufacturing plant in Allentown, Pennsylvania. According to a report in *Newsweek*, the plant once housed 700 women who manually assembled transistors in old, airy rooms. Today, workers monitor computer consoles in "clean cells that filter out dust and humidity." In the same article, Robert Lund, assistant director of the Center for Policy Alternatives at the Massachusetts Institute of Technology, observed that as a result of installing automated equipment in one firm, "the skills required went down, but the pay went up." In this case, the salary was determined by the need to attract responsible workers to a boring job rather than by the skills required for performing the work.

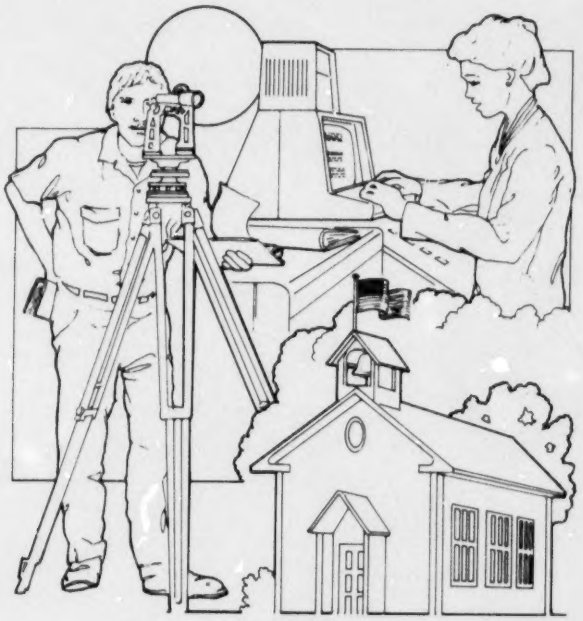
In examining a more pervasive innovation, three scholars in Great Britain, Erik Arnold, Lynda Birke, and Wendy Faulkner, have defined the ways in which word processing deskills the job of typing:

> Even typing itself involves varied tasks at present: changing paper, typing, arithmetic for text centering, page layout and so on. Word processors deskill typing tasks by means of such facilities as easy correction, automatic text centering and automatic layout. Thus, while still requiring some basic ability to operate a standard keyboard, word processors dispense with the need for layout skills and high levels of keystroke accuracy.

If technology has the effect of making certain jobs less challenging and more tedious, education may have an important role to play apart from the teaching of basic skills. When work is not satisfying, avocational interests assume greater significance. A broader, more adaptive view of life (the result, many argue, of a liberal education) may provide workers in jobs deskilled by technology with the ability to find other meaning in life.

How do we reconcile, then, the two seemingly opposing views of the skills needed for work in the world of high technology? Both perceptions —that technology requires a higher level of skills and that technology deskills many jobs— seem to be at least partially accurate.

Certainly those who are responsible for the design of technological innovations and those who manage the production of goods and services need to understand and be able to control the machines that are daily changing our lives. And even the average worker in the service-producing industries will need skills that may not be currently required, such as the ability to think critically and manipulate data. The skilled or semi-skilled worker in the goods-producing sector, on the other hand, would seem to require fewer of the skills of craftsmanship that characterize



the accomplishment of labor-intensive work. Rather, employers expect these workers to have a well-developed sense of responsiblity and the inclination to follow very specific instructions in tending the machinery of capital-intensive production processes.

Skill Requirements

The review of the literature for this article revealed over and over that employers, in discussing the needs of modern business and industry, are actually emphasizing the need for basic skills, rather than highly specialized or technical skills. When interviewed by Thomas Toch for *Education Week*, Sol Hurwitz, senior vice president of the Committee for Economic Development (a public-policy organization representing 200 major corporations), spoke of employers' concerns about the preparation of students in schools: "There's a widespread feeling within the business community that the schools have failed to produce students who can communicate, who can listen and think, and who can work with other people." Moreover, a report in *School Business Affairs* on a word-processing program offered at a Milwaukee (Wisconsin) high school indicates that students enrolling in the program lacked basic skills required for word processing, such as the ability to spell and punctuate properly, knowledge of proper sentence construction, and the use of correct grammar.

Additionally, in a recent analysis of the impact of new electronic technology on jobs, Richard Riche suggested that the emphasis now is on formal knowledge, precision, and perceptual attitudes. These skills rely on the ability to read and write on a functional level in order to interpret the operating manuals of complex equipment and to facilitate retraining in new skills.

Generally, then, the skills described by these writers, and echoed by business leaders generally, should be mastered at the secondary level. If, indeed, students are graduating from high schools without these skills, the answer would seem to lie in the restructuring of secondary education. In fact, high schools are already under pressure to raise their standards for student promotion and graduation as colleges nationwide consider stiffening entrance requirements.

At the same time that high schools strengthen their basic curriculum, however, they will also need to ensure that highly specialized and technical courses are available for those who need them. Training in such fields as higher math and science, electronics, and advanced computer programming is essential to the preparation of those seeking to become researchers, designers, and managers of technological systems.

Both perceptions—that technology requires a higher level of skills and that technology deskills many jobs—seem to be at least partially accurate.

The provision of "elite" classes is perennially at odds with our concept of equity. To prevent the further polarization of skills between workers and managers described by Braverman, careful consideration will have to be given to the question of access to and sequential tracking for these highly specialized classes. In addition, some adjustments will need to be made in the workplace to avoid widespread alienation and dissatisfaction among those in routinized jobs.

Science and Math

Present educational planning attempts to look ahead and evaluate the effects of the computer and other technology on the symbiotic relationship between education and work. Attention has focused on the need for more and better instruction in math and the sciences as a foundation for understanding and using the sophisticated tools of the future. In addition, a smaller, less strident voice is being raised in support of increased foreign language requirements and international studies programs to facilitate two-way communication with a world no longer content to consider English as the only language of diplomacy and commerce. And not least of the needs spawned by the technological revolution is the ability to locate, evaluate, and adapt information to specific purposes. These skills, say many, are imparted through a broad rather than a technical curriculum.

A cursory look at any newspaper or popular magazine today is all that is needed to show that the educational and business establishments and the federal government are concerned about the shortage of graduates in science and math. Of special concern is the need for elementary and secondary teachers trained in these disciplines, particularly in higher

math and the physical sciences.

This concern was manifested and given nationwide publicity during the National Academy of Science's National Convocation on Precollege Education in Science and Mathematics held in Washington, D.C., May 12-13, 1982. In his address, which has been quoted repeatedly, Paul Hurd of Stanford University deplored the failure of Americans

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to appreciate the importance of science and math to economic and cultural progress. He stated that other nations, such as the Soviet Union, East Germany, and Japan, offer specialized instruction in science and math beginning in the fourth grade. Students in those countries spend up to three times as many class hours on the two disciplines as American students.

An analysis of survey results on the knowledge and skills of American 17-year-old students by the National Assessment of Educational Progress (NAEP) reveals some specific weaknesses in the mathematical ability of the nation's youth. According to authors Gisi and Forbes, from 1973 to 1978 students declined in their demonstration of mathematical understanding, their use of mathematical applications, and their ability to complete multistep math problems. In general, the NAEP surveys suggest that "students have acquired very few skills for examining ideas. Many are capable of preliminary interpretations, but few are taught to move on to extended comprehensive and evaluative skills."

The NAEP results and the higher-level thinking skills required by a technological society that is increasingly devoted to the processing of information point inevitably to needed curriculum reforms. Gisi and Forbes argue that "with technological devices pervading everyday lifestyles, students who are not planning a technical career will need an understanding of the basic principles underlying their operations." By the same token, the thinking, evaluative, and comprehension skills needed for future work are not necessarily covered in a technical course of study. Future workers at all levels will need to understand the workings of entire systems, not

Students have acquired very few skills for examining ideas. Many are capable of preliminary interpretations, but few are taught to move on to extended comprehensive and evaluative skills.

just of their specific duties. The increasing interdependency of technology and communications demands that workers approach their work with a sense of perspective and avoid giving too much importance to any one set of responsibilities.

These overlapping needs suggest the efficacy of providing a basic core curriculum for all students. The emphasis should be on the interrelated nature of multidisciplinary skills. James O'Toole sees a continued, if not more pressing, need for broadly educated workers:

> The problems most people face at work are complex, interdependent, and above all have to do with working with people cooperatively and ethically. Most of the really tough problems that people encounter at work are not technical — the computer can be made to solve those. Indeed, the toughest questions are not problems at all, if a problem is defined as having a single solution. For there are no solutions to the tough policy and organizational problems of work— there is only a spectrum of alternative responses. . . It is such problems that a broadly educated, truly enculturated worker is best equipped to handle.

A Broad-based Curriculum

It is a temptation, in time of crisis or substantial change, to concentrate on one answer to a problem, even in answer to those problems that, according to O'Toole, do not have a solution. Consequently, during the current preoccupation with technology and specialization, it is important to be reminded of those skills found to be productive that are not part of any one discipline.

Gisi and Forbes, O'Toole, Sol Hurwitz, Richard Riche and others previously cited in this paper have reiterated the need for critical thinking skills in workers of the future. Many employers talk in abstract terms about the poor problem-solving capacities of young workers. O'Toole makes an important distinction between problem-solving as we have visualized it in the past and problem-solving as it will be

required in the future. He foresees that workers trained in unidimensional problem-solving methods, such as cost-benefit analysis and statistical regression, will become anachronistic as computers take over routine problems treatable by formulaic solutions. Instead of finding tidy answers to recurrent problems, O'Toole envisions future workers facing "intransigent systemic" problems —energy, food availability, unemployment, urban decay— that "cannot be solved by empirical trial and error or reduced to mathematical precision... Perhaps it is not problem solving at all that is needed in business, government, and academia, but problem identification and definition."

Adaptability appears to be one essential quality demanded by rapid technological change.

An important attribute identified with a broad education is the ability to adapt to change. Often, the narrowly trained specialist finds such adjustments more difficult than does the more generally trained worker. O'Toole reports,

> Significantly it is starting to dawn on corporate leaders that they need broadly and liberally educated employees. In the last two decades, corporate recruiters and personnel managers have been hiring narrowly trained specialists to fill lower-level openings. While these new hires meet the immediate needs of a firm, as time goes along it becomes clear that they are not promotable. Thus American corporations now are being forced to spend hundreds of millions of dollars on employee education in a not terribly successful effort to prepare lower- and middle-level employees to assume greater responsibility.

Industrialist William Agee has also articulated the need for a wide range of abilities to function competently in the business world. In an address to a national meeting of business educators, he remarked, "I would hope that you are working hard at producing more than a student of business. Clearly, managers of the eighties must be political animals... The business of business today is the whole sociopolitical economy."

The Role of Vocational Education

During the current recession, marked by declining productivity growth and unprecedentedly high levels of unemployment, interest has grown in the roles vocational education and other alternatives can play in reversing both of these trends. Gene Bottoms, executive director of the American Vocational Association, sees the new Job Training Partnership Act as giving added support to vocational education. The resources of local vocational programs, he contends, are the "logical choice for serving the economically disadvantaged," who comprise a disproportionate share of the unskilled and unemployed labor pool.

Support for the status quo in vocational and career education programs, however, will not be sufficient. Several researchers have questioned the effectiveness of vocational programs and others have detected socioeconomic repercussions that operate counter to the goals of educational equity.

Shortcomings in vocational education as currently conceived include its often narrow focus on training in specific skills and the frequent neglect of affective and thinking skills valued by most employers. In *Work in America*, written by O'Toole and others, Beatrice Reubens reported the results of an evaluation showing that the initial employment record of vocational graduates —in terms of income, job status, turnover, upward mobility, unemployment rates, and job satisfaction— is no better than that of students graduating from academic programs. This may partially be explained by the argument that skills taught in vocational programs are not general enough for use in a rapidly changing world and are often obsolete before the students secure their first jobs.

Additionally, O'Toole has found that vocationally trained workers have difficulty adapting to the more democratic forms of self-management that are expected to pervade American industry in the future. He sees an inadequacy on the part of these workers in dealing with nonroutine conditions and contends that employers will require more "analytical and entrepreneurial skills, people who know how to solve problems, and people who will not panic when something untoward starts to occur at places like Three-Mile Island." Moreover, he continues, "People who are vocationally trained to unquestioningly perform a single task are manifestly unprepared to design their own work, participate in decision making, assume control over their own working conditions, work as members of a community of equals, or take

responsibility for the quantity and quality of their own work when a boss is not looking over their shoulders."

Approaching the subject of vocational education from another perspective, John Goodlad, dean of the UCLA Graduate School of Education, has studied the distribution of secondary curricular opportunities compared to the distribution of teachers by specialty. His findings, to be published at the end of February 1983 in a book entitled *A Place Called School*, indicate that there is enormous variability in the assignment of teachers and that vocational education teachers comprise a disproportionate share of the teaching force —24 percent in senior high schools. In some schools, vocational education teachers constitute over 40 percent of the teaching force.

According to Goodlad, vocational education enjoys curricular luxury as a result of this distribution. Vocational teachers teach their specialty while English, math, and social studies teachers are "spread all over the place." He attributes the inconsistent allocation of the teaching force to the fault of omission rather than to conscious design.

In response to this forceful indictment, others suggest that vocational education, offered as a choice rather than a necessity may help to keep students who are not academically inclined from dropping out of school. Concurrently, they express the need for a *modern* program of vocational education to provide skills for those having little interest in or aptitude for academic work. And although Russell Rumberger of Stanford University has found that for students who do not attend college, differences in high school curriculum appear to have little effect on employment opportunities, he did determine that there were payoffs to certain specific vocational programs when the training was actually utilized in later jobs, especially in programs training for office occupations. He concludes, therefore, that both vocational and academic curricula show positive results in specific circumstances.

There is a pressing need to evaluate the type of curriculum that will best prepare students not for specific jobs but for a range of tasks that will be required by society and industry in the near future.

The National Center for Research in Vocational Education at Ohio State University has investigated the effects of participating in a vocational curriculum. In 1981, research staff at the center examined almost 1,500 studies covering such topics as earnings, employee satisfaction, academic achievement, and basic skills attainment. The literature surveyed indicated that a majority of vocational education graduates found employment related to their technical training, particularly in the fields of business, office, and health education. In addition, vocational graduates were found to be confident in their skills.

There is also evidence that vocational educators are interested in incorporating more general skills, such as those O'Toole emphasizes, into their programs. Stuart Rosenfeld, director of research and programs for the Southern Growth Policies Board in Research Triangle Park (North Carolina) refers to a "generic" approach to vocational education that results in a closer connection to the regular secondary program. According to Rosenfeld, vocational agriculture exemplifies for some a successful model encompassing less specialized and more integrated training. He states that by "combining farming, business, and problem-solving skills with strong leadership training, vocational agriculture has contributed to large gains in productivity."

Conclusion

Technology has substantially affected our perceptions of how much education is desirable or required to keep pace with current and forecasted changes. Some researchers suggest that skill levels are rising and will need to continue doing so. Others argue that the actual skill levels required for technological work are lower than those required for manual work. Both arguments support the notion that human knowledge and skills are important determinants of economic productivity, but they differ over the types of skills that should be stressed in schools.

Those who believe there is a shortage of job-specific or highly specialized skills give impetus to the movement toward more vocational training in the schools. On the other hand, those who believe that work in general is becoming deskilled emphasize the importance of a broad course of studies to develop the potential of the whole person. They see vocational training as a way of

narrowing student competencies and lowering expectations, in other words, of tailoring the skills of workers to the requirements of the workplace without concern for other human needs.

The evidence presented here is not intended to suggest that every student should become a generalist. What it does indicate is a pressing need to evaluate the type of curriculum that will best prepare students not for specific jobs but for a range of tasks that will be required by society and industry in the near future.

Adaptability to change appears to be one essential quality demanded by rapid technological change. Educators must consider to what degree a curriculum that is becoming increasingly specialized at the secondary and postsecondary levels will produce workers who are flexible and able to adjust to continuing transformation in the tools and conditions of work.

The other skills identified as important to modern society —analysis and critical thinking, organizational and reference skills, creativity, and the ability to communicate interpersonally and internationally— call for general training in addition to specialized training. The former should furnish a foundation for the latter. Therefore, the core curriculum that is designed to provide this general foundation should be emphasized in the formative elementary and secondary years and protected from encroachment by peripheral studies. At the same time, high schools will need to prepare a sufficient cadre of highly skilled students in technical fields who are college bound, for our society requires not only competent users of technology, but also technological innovators at ease with complex systems.

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